Fishery Manuscript Report No. 98-3

Abundance and Composition of Sheefish in the Kobuk River, 1997

by

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and

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December 1998

Alaska Department of Fish and Game **Division of Sport Fish**

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
ounce	oz
pound	lb
quart	qt
yard	yd

Spell out acre and ton.

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
minute	min
second	s

Spell out year, month, and week.

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

All commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.
All commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.
and	&
at	@
Compass directions:	
east	E
north	N
south	S
west	W
Copyright	©
Corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
et alii (and other people)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.,
id est (that is)	i.e.,
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
number (before a number)	# (e.g., #10)
pounds (after a number)	# (e.g., 10#)
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)

Mathematics, statistics, fisheries

alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	F, t, χ^2, etc.
confidence interval	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
standard length	SL
total length	TL
variance	Var

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December 1998

Development and publication of this manuscript were partially financed by the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under Project F-10-13, Job R-3-5(b).

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This document should be cited as:
Taube, T. T.and Wuttig, K. 1998. Abundance and Composition of Sheefish in the Kobuk River, 1997. Alaska Department of Fish and Game, Fishery Manuscript Report No. 98-3, Anchorage.

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ABSTRACT

The goal of this study was to determine the stock status of spawning sheefish *Stenodus leucichthys* in the upper Kobuk River. The study objectives were to estimate abundance, and length and age compositions of spawning sheefish in a 130 km reach of the upper Kobuk River and to estimate harvest of the subsistence gillnet fishery on Hotham Inlet. Sampling in the Kobuk River was conducted July 28 - September 29, 1997. Sheefish were collected by hook and line and beach seine. Length, sex, and age data were collected and sheefish were marked with a Floy tag. Sheefish caught in the subsistence fishery were examined for tags and sampled for length, sex, and age data. Sheefish examined ranged from 8 to 21 years of age. The largest proportion of female sheefish was age 13 and age 11 for males. The 925 mm (901 – 925 mm) category had the largest proportion of female sheefish, while the 775 mm category had the largest proportion of males. An estimated 32,511 (24,480 - 40,542 90%CI) sheefish were in the area between Kobuk Village and Reed River prior to spawning. A survey of the subsistence and commercial gillnet fisheries in Hotham Inlet was conducted in April and May 1997. Eighteen of 22 participants in the subsistence gillnet fishery on Kobuk Lake were interviewed and the total harvest for the 1996 - 1997 subsistence gillnet fishery was estimated at 13,704 sheefish (95% CI 9,880 - 17,528). Tag returns from previous years were inconclusive for estimates of spawning frequency by sex.

Key words: sheefish, *Stenodus leucichthys,* Kobuk River, abundance estimate, length composition, age composition, spawning frequency, subsistence gillnet harvest.

INTRODUCTION

Sheefish, *Stenodus leucichthys* or inconnu of the Kobuk/Selawik river drainages are considered estuarine anadromous (Alt 1987). The populations have a common overwintering area in Hotham Inlet and Selawik Lake. Spawning grounds are in the upper Kobuk and Selawik rivers (Figure 1). This was the final year of a 4-year (1994 – 1997) study focused on the abundance estimation of the Kobuk River spawning population; a concurrent 4-year (1993 – 1996) study was conducted by the US Fish and Wildlife Service (USFWS) on the Selawik River spawning population. Genetic work conducted in 1994 by the USFWS from samples collected from both the Kobuk and Selawik rivers spawning area indicate that separate spawning stocks exist (Miller et al. 1998).

Kobuk River sheefish migrate long distances upstream to reach spawning areas in late fall, approximately 575 to 650 km upstream of Hotham Inlet. The spawning migration of mature sheefish in the Kobuk River is an extension of the seasonal feeding migration of the population, which begins soon after ice breakup in the spring. Sheefish move upstream rapidly, reaching Kiana, 100 km upstream from the mouth of the Kobuk River, by late June (Figure 1). Nonspawners seldom migrate more than 180 km upstream from the mouth of the Kobuk River, but spawners continue upriver reaching Ambler in mid-July. As fish reach Ambler, 265 km upstream from the mouth of the Kobuk River, the migration slows and fish disperse. They reach spawning areas between Kobuk Village and Reed River (544 to 672 km upstream from the mouth of the Kobuk River) from August through early September. Spawning occurs a few days prior to the beginning of freeze up (appearance of frazzle ice). A downstream migration occurs after spawning (Alt 1969 and 1987). Alt (1987) found only one nonspawning sheefish (< 0.01% of all sheefish examined) in the vicinity of the spawning grounds. It is therefore assumed that all sheefish encountered above Kobuk Village will be spawners.

The Kobuk/Selawik population contains the largest sheefish in Alaska; individuals up to 26.5 kg have been captured (Alt 1987). Because of their large size and relatively easy access, Kobuk

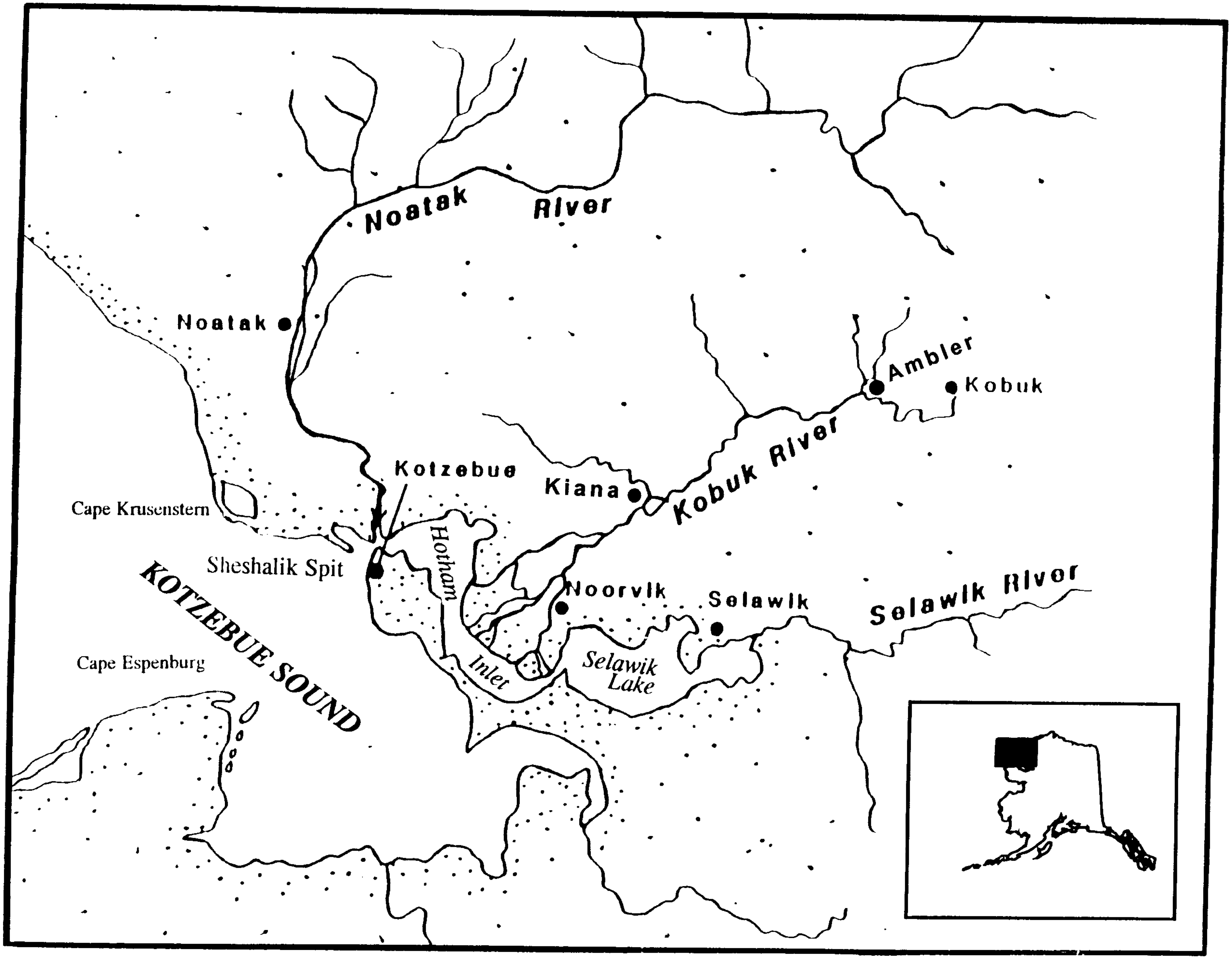

Figure 1.-Map of Kobuk River and surrounding area.

River sheefish are highly sought by sport anglers. Since the inception of the Alaska Department of Fish and Game (ADF&G) trophy fish program in 1967 through 1997, 13 of 15 trophy sheefish registered have been taken from the Kobuk River. All official Hall of Fame 1996 world fresh water fish records of North America (tackle and line class) for sport angled sheefish are from fish caught in the Kobuk River (National Fresh Water Fishing Hall Of Fame, Hayward, Wisconsin).

Estimated sport fish harvests of these fish from the Kobuk River from 1977 to 1996 have averaged 786 fish, ranging from 131 in 1989 to 1,886 in 1982 (Mills 1979 - 1994, Howe et al. 1995 - 1997). During this time period sheefish from the Kobuk River have accounted for 34% of the statewide sport harvest of sheefish and 60% of the sport harvest of sheefish for northwestern Alaska. Estimated sport fish catches of these fish from the Kobuk River from 1990 to 1996 have averaged 1,316 fish (Mills 1991 - 1994, Howe et al. 1995 - 1997). During this time period the Kobuk River has accounted for 27% of the statewide and 67% of the northwestern Alaska sport catch of sheefish.

Current sport fishing regulations for sheefish in the Kobuk River are: two per day, two in possession, with no size limit for sheefish upstream of the mouth of the Mauneluk River and 10 per day, 10 in possession, with no size limit for the remainder of the Kobuk River. Prior to 1988 the sport fishing regulations for sheefish in the Kobuk River were 10 fish per day, no possession limit, and no size limit. Concerns for the maintenance of this sheefish stock and continuance of this unique trophy fishery were the motivation behind these proposals submitted by ADF&G to and adopted by the Alaska Board of Fisheries in 1987.

In addition to supporting an important sport fishery in the Kobuk River, Kobuk/Selawik sheefish are taken in both subsistence and commercial fisheries (Appendix A). The subsistence fishery occurs throughout the Kotzebue District, which includes the Kobuk and Selawik rivers, Selawik Lake, and Hotham Inlet (Lean et al. 1996). The major harvest occurs in the subsistence fishery with reported harvests as high as 31,292 sheefish (Lean et al. 1996). Currently the subsistence fishery is not regulated. The subsistence harvest reports are incomplete and should be considered minimum harvest numbers. Prior to 1994, subsistence harvest was not the estimated harvest of all fishery participants, but only the harvest of the participants interviewed. In addition, in many years the reported subsistence harvest was from the Kobuk River villages and not the Kotzebue District as a whole, which includes winter gillnet and spring hooking fisheries on Hotham Inlet and Selawik lakes. From 1967 through 1996 the estimated commercial harvest has averaged 1,257 fish. Lean et al. (1996) suggests that commercial harvests have remained relatively high, due to underreporting. It is suspected that the undocumented commercial harvest is significant and totals should be considered minimum estimates. Lean et al. (1996) reported that during the 1960's, age, sex, and length data indicated sheefish stocks were being overharvested by commercial and subsistence fisheries in the Kotzebue district. Consequently, an annual area commercial harvest quota of 25,000 pounds of sheefish was instituted.

Prior to this study, data on the number of sheefish spawning in the Kobuk River are intermittent and the result of aerial surveys conducted by ADF&G Division of Commercial Fisheries Management and Development (CFMD). Between 1966 and 1971, aerial counts averaged 3,706 and ranged from 1,025 to 8,166 (Alt 1987). Intermittent aerial counts since 1979 (1979, 1980, 1984, 1991, and 1992) have averaged 5,617 and have ranged from 1,772 to 17,335 (Lean et al. 1996). A mark-recapture experiment conducted in 1970 estimated 7,130 spawners, while an aerial survey in 1970 counted only 3,220 spawners (Alt 1987). In 1995 and 1996, mark-recapture experiments were conducted on the Kobuk and Selawik rivers by Sport Fish Division (ADF&G) and USFWS. From these studies, estimates of spawning sheefish on the Kobuk and Selawik rivers were 32,273 and 5,190 in 1995 and 40,036 and 5,157 in 1996, respectively (Taube 1996, 1997, Underwood 1998).

Past work on sheefish in Alaska was summarized by Alt (1987) and includes data on the ecology, movements, growth, and stock status of all known Alaskan stocks. The Subsistence Division (ADF&G) investigated conflicts (real and perceived) between user groups on the upper Kobuk River in 1989 (Georgette and Loon 1990). Prior to 1994, the Sport Fish Division has had no projects directed toward Kobuk River sheefish since 1979.

The goal of this project was to describe the stock status of spawning sheefish in the upper Kobuk River. In order to accurately and precisely describe the stock status of spawning sheefish in the upper Kobuk River, project objectives for the 1997 Federal Aid project F-10-13, R-3-5(b) were to estimate:

1. the abundance of sheefish spawning in a 130 km reach of the upper Kobuk River;
2. the length and age compositions of sheefish spawning in a 130 km reach of the upper Kobuk River;
3. the relative contribution of spawning sheefish that were marked and released between Kobuk Village and Reed River in 1995 and 1996 and recovered in 1997; and,
4. the harvest of the 1996-97 subsistence and commercial gillnet fisheries at Hotham Inlet.

METHODS

DATA COLLECTION

The study area for the abundance estimate consisted of a 130 km stretch of the Kobuk River divided into three sections: 1) Kobuk Village to the Mauneluk River (48 km or 30 miles); 2) Mauneluk River to the Selby River (32 km or 20 miles); and 3) Selby River to the Reed River (50 km or 31 miles) (Figure 2). Sampling occurred from July 28 - September 29, 1997, throughout the study area.

The marking event occurred from July 28 - September 17 and the recapture event occurred from September 18-29. Sheefish were sampled using hook and line and a 61.5 m beach seine during both events. In addition, the subsistence gillnet fishery was sampled during the recapture event. The start of the recapture event in 1997 occurred when catch rates of sheefish in section one were essentially zero and it was assumed that all spawners were within the study area. This coincided with the subsistence fishery beginning to target sheefish in their gillnets. Effort was distributed in all three sections of the study area during both mark and recapture events.

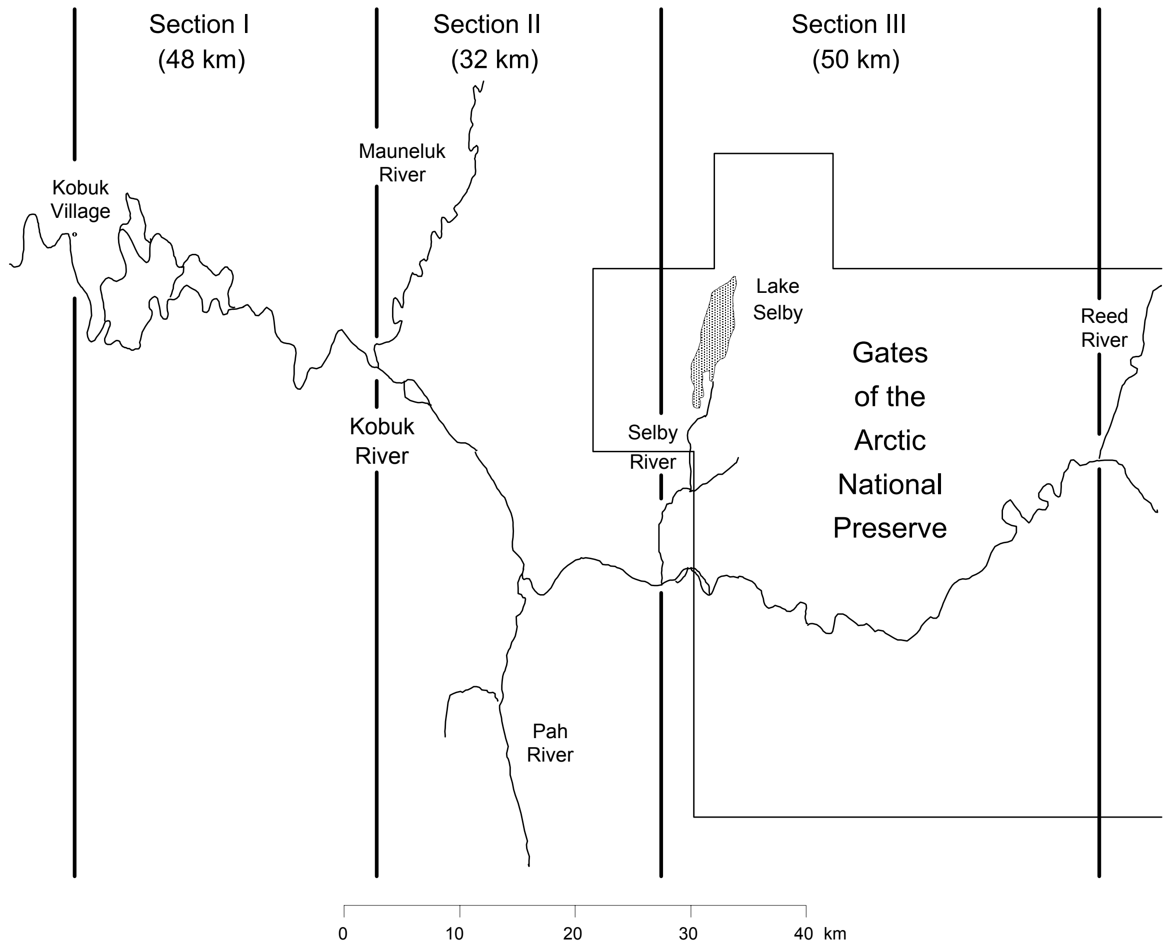

Figure 2.-Area of the Kobuk River sampled for sheefish in 1997.

A crew of four to six persons sampled sheefish with hook and line from two boats (two to three crewmembers per boat). Sheefish were located and caught primarily in the main channel of the Kobuk River in moderate velocity water off the river bottom. Length, sex, tag number, finclip, date, and river mile were recorded on Tagging Length Version 1.0 mark-sense forms. All captured sheefish were examined for Floy tags and prior finclips and measured to the nearest millimeter of fork length. During both events, untagged sheefish judged to be in a healthy condition were released after being marked with an individually numbered Floy FD-67 internal anchor tag inserted at the base of the dorsal fin so that the tag locked between the posterior interneural rays. All fish marked with a Floy tag were also marked with a upper caudal fin clip in case tag loss occurred between events. The sex and maturity of each live fish was determined by the presence of sex products. Fish for which sex could not be determined were recorded as neither male nor female. Sheefish were landed as expediently as possible and usually processed in less than 30 s. Fish were then held in the water, head facing the current and released once they were judged to be in a healthy condition. Fish that were injured or severely bleeding were not tagged. During the marking event, a concurrent hooking mortality study was conducted (Stuby and Taube, 1998); fish released from this study were included in the marked sample for the abundance estimate. At least three scales were taken from the left side of the body just posterior of the dorsal fin approximately midway between the lateral line and the base of the dorsal fin (Alt 1969). Scales of sheefish captured by hook and line were immediately mounted onto gum cards labeled to correspond to the mark-sense forms. Due to handling time constraints, scales of sheefish captured by seine or gillnet were placed into coin envelopes for later mounting onto gum cards. Coin envelopes were labeled appropriately to correspond with the mark-sense forms. The scales were mounted onto gum cards and impressions were made on 20 mil acetate sheets using a Carver press at 241,315 kPa (35,000 psi) heated to 145° C for 135 s. The acetate sheets were then consecutively numbered and sheets were randomly selected until the sample size was achieved. Scales from 528 sheefish captured by hook and line and 532 sheefish captured by seine were aged. Scales were read on a Micron 770 microfiche reader (32X). Annulus determination was made using criteria described by Alt (1969). Ages were then recorded into the edited data file.

When sheefish mortalities occurred, paired samples of scales and otoliths were collected for age comparison. Scales were aged as described above and one otolith from each fish was aged using the break and burn technique (Chilton and Beamish 1982). A sample of 10 otoliths were aged by both thin section aging and the break and burn technique. Microprobe analysis was also conducted on a otolith from a male and female sheefish to determine if time was spent by Kobuk River sheefish in high salinity water (ie. sea water). High levels of strontium can indicate time spent in high salinity water.

Sheefish sampled by beach seine were processed in the manner described above. One boat and a crew of at least four were used during seining. Sheefish were found and seined in shallow (< 2.0 m), high velocity water, usually on the downstream end of a gravel bar. A rope harness was attached to each end of the seine with a 16-m lead. One or two crewmembers remained on the upstream portion of the gravel bar holding one lead, while the remaining crew pushed the boat into the current. The seine was set as perpendicular (crosscurrent) to the shore as possible, while the current took the boat downstream. To accomplish this, the onshore crewmembers would walk the net down the shoreline, until all the net was out and the boat motored the other lead to shore. The ends of the leads were brought together and the seine was pulled to shore. A portion of the seine was left in the water to hold the captured sheefish, until all were processed. Due to the swift current, several hundred yards of shoreline was required to dispatch and haul in the seine.

Sheefish caught in the subsistence fishery were examined whenever the subsistence users granted permission. These fish were examined for tags and secondary marks, length and sex were recorded and scale samples were taken.

A survey of participants in the Hotham Inlet (Kobuk Lake) winter gillnet fishery was begun in April and completed in May by ADF&G Sport Fish and CFMD personnel. All individuals who participated in the subsistence and commercial gillnet fishery were contacted by phone or in person. Participants were not interviewed until after their gillnets were pulled for the season. A questionnaire was completed for each individual interviewed. Names of the participants were not recorded on the questionnaire to insure anonymity. A copy of the questionnaire is found in Appendix B.

ABUNDANCE ESTIMATION

The number of sheefish spawning in the Kobuk River was estimated using the Bailey modification of the Petersen estimator (Seber 1982). Population abundance and the approximate variance of the estimate was calculated with the following formulas (Seber 1982):

$$\hat{N} = \frac{M(C+1)}{(R+1)} \text{ and} \tag{1}$$

$$V\left[\hat{N}\right] = \frac{M^2(C+1)(C-R)}{(R+1)^2(R+2)} \tag{2}$$

where:

M = the number marked during the first sampling event;

C = the number examined during the second sampling event; and,

R = the number captured during the second sampling event with marks from the first sampling event.

A two event mark-recapture experiment on a closed fish population is unbiased if the following conditions are met:

1. catching and handling the fish does not affect the probability of recapture;
2. fish do not lose marks between events;
3. recruitment and mortality do not occur between sampling events (recruitment or mortality can occur, but not both);
4. every fish must have an equal probability of being marked and released alive during the first sampling event; or every fish must have an equal probability of being captured during the second sampling event; or marked fish mix completely with unmarked fish between sampling events (Seber 1982).

Condition 1 was met because only sheefish that were judged to be in good condition after capture were marked prior to being released. Condition 2 was met by double marking each fish (Floy tag and finclip) in order to determine if marks were lost between events. To meet condition 3, the recapture event coincided with the targeting of sheefish by the subsistence fishery, any mortality that occurred during the marking event was assumed to be negligible. In addition, there was essentially no hiatus between events (one day), and it was therefore assumed that mortality did not occur between events. However, there was a possibility that not all pre-spawning sheefish were on the spawning grounds prior to initiation of the marking event and as such condition 3 would be violated. Marked-to-unmarked ratios by each river section during each week of the recapture event were evaluated to determine if recruitment to the population had occurred. Since the recapture event was only 11 days in length, week 1 of the recapture event was seven days in length and week 2 was four days in length.

To evaluate condition 4, the marked-to-unmarked ratio in sections 2 and 3 during the recapture event was compared using the Chi-square statistic and contingency table (no sheefish were captured in section 1 during the recapture event). Movement and/or mixing of marked sheefish with unmarked sheefish was determined by visual comparison of the frequency of recaptured fish that moved from one river section to another.

The hypothesis of equal probability of capture of fish by size between each sampling event was tested with Kolmogorov-Smirnov two sample tests. The first test involved the lengths of marked fish recaptured during the recapture event versus the lengths of those fish marked during the marking event. The second test compared the lengths of fish marked during the marking event with fish examined during the recapture event (Seber 1982).

The Chi-square statistic was used to determine if size selectivity occurred between gear types. The hypothesis of equal probability of capture by gear type and the probability of fish marked with one gear being recaptured with another was tested with the Chi-square statistic.

Estimates of contribution to 1997 spawner abundance of spawning sheefish marked in 1995 and 1996 were calculated as follows:

$$\hat{p}_t = \frac{m_t}{\hat{N}} \tag{3}$$

$$\hat{p}_m = \frac{c_m}{n_m} \tag{4}$$

$$\hat{p}_c = \frac{\hat{p}_m}{\hat{p}_t} = \hat{p}_m \hat{N}\left(\frac{1}{m_t}\right) \tag{5}$$

where:

m_t = marked fish in population 1;

$\hat{N}$ = estimated size of population 1;

c_m = number of marks from population 1 found in population 2;

n_m = number of fish examined for marks in population 2;

p_t = proportion marked and released in population 1;

p_m = proportion of marked population 1 fish in population 2; and,

p_c = contribution, the proportion of population 2 that came from population 1.

The estimate for the exact variance (Goodman 1960) of $\hat{p}_c$ is:

$$\hat{V}(\hat{p}_c) = \frac{1}{m_t^2}\left[\hat{N}^2\hat{V}(\hat{p}_m) + \hat{p}_m^2\hat{V}(\hat{N}) - \hat{V}(\hat{p}_m)\hat{V}(\hat{N})\right]. \tag{6}$$

Age and Length Composition

Estimates of length and age composition were calculated as follows (Cochran 1977):

$$\hat{p}_j = \frac{n_j}{n} \text{ and} \tag{7}$$

$$\hat{V}\left[\hat{p}_j\right] = \frac{\hat{p}_j\left(1-\hat{p}_j\right)}{n-1} \tag{8}$$

where:

n_j = the number in the sample from group j;

n = the sample size; and,

$\hat{p}_j$ = the estimated fraction of the population that is made up of group j.

The estimated abundance of each group j in the population is:

$$\hat{N}_j = \hat{p}_j\hat{N} \tag{9}$$

where:

$\hat{N}_j$ = the estimated number of fish in the population in group j; and,

$\hat{N}$ = the estimated population.

The variance of $\hat{N}_j$ is the exact variance of a product (Goodman 1960); (subtracted term ignored since one term has an exact variance and the other term has a sampling variance as per D. R. Bernard, Alaska Department of Fish and Game, personal communication):

$$\hat{V}\left[\hat{N}_j\right] = \hat{V}\left[\hat{p}_j\right]\hat{N}^2 + \hat{V}\left[\hat{N}\right]\hat{p}_j^2. \tag{10}$$

SUBSISTENCE GILLNET HARVEST

The estimated harvest of the subsistence and commercial gillnet fishery and the approximate variance of the estimate was calculated with the following formulas (Cochran 1977):

$$\hat{y} = N\bar{y} \text{ and} \tag{11}$$

$$V(\hat{y}) = \frac{N^2 s^2}{n}\left(1 - \frac{n}{N}\right) \tag{12}$$

where:

$\hat{y}$ = estimated gillnet fishery harvest;

N = the total number of gillnet fishery participants;

n = the number of participants reporting harvest;

$\bar{y}$ = the estimate of the mean reported harvest; and,

s = the variance of the reported harvest.

RESULTS

Abundance Estimation

Sampling during the recapture event involved examining the subsistence gillnet catches of the Kobuk River village fish camps. There was no distinct schedule for the subsistence users to pick their nets and often the nets were picked and sheefish already placed in holding cribs, by the time the sampling crew arrived at the net sites. Out of respect to the native culture, the sampling crew were unable to sample the sheefish for length and sex data, but catch numbers and tag recoveries were possible. Unfortunately, to test for size-selectivity, lengths were required, so only sheefish that were sampled for length data are included in the abundance and composition estimates.

A total of 1,757 sheefish were marked during event 1, and 743 sheefish were examined during event 2 (Table 1). Thirty-nine marked sheefish were recaptured during the second event, 23 by seine, 16 by gillnet and 0 by hook and line. Hook and line sampling during the second event captured only 40 sheefish, and none of these were marked during the first event. In 1996, three sheefish were captured by hook and line during the second event, but no sheefish were captured by hook and line during the same event in 1995. Taube (1997) determined that sheefish catchability by hook and line decreases as the spawning period approaches, and based on the period the second events occurred, this was the cause for low catch rates by hook and line in 1995 and 1997. Sampling by hook and line during the second event was not a primary sampling method, it was conducted only when searching for new seining sites or while waiting to sample subsistence nets. Therefore, for testing the marked to unmarked ratios during the second event, hook and line was excluded from the analysis. There was not a significant difference in marked

Table 1.-Sheefish marked, examined, recaptured, and R/C ratio by event, gear type, and river section for the 1997 sampling period.

		Event 1	Event 2		
		7/28 – 8/6/97 8/15/97 - 9/17/97	9/18 – 29/97		
Gear Type	River Section	Sheefish marked (M)	Sheefish examined (C)	Sheefish recaptured (R)	R/C
Seine	1	0	0	0	0
	2	27	0	0	0
	3	42	446	23	0.052
	Total	69	446	23	0.052
Hook & Line	1	599	0	0	0
	2	1,078	4	0	0
	3	8	36	0	0
	Total	1,685	40	0	0
Gillnet	1	0	0	0	0
	2	0	124	12	0.097
	3	0	130	4	0.031
	Total	0	254	16	0.063
Total		1,757	740	39	0.053

to unmarked ratios between the two gear types during event 2 (χ^2 = 0.455, P = 0.50). No sheefish were captured in section 1 during the second event, although sampling effort occurred in that section. Since sampling effort was distributed throughout the study area, it was assumed that the majority of sheefish had moved out of section 1 and into sections 2 and 3.

Only 4% of sheefish marked during event 1 were captured by seine, the remaining 96% were captured by hook and line. The majority of seining sites were located in section 3 and sheefish were not at these sites in sufficient numbers to seine during event 1. In addition, high water during event 1 caused sheefish to disperse at sites that were effective for seining in 1996 and resulted in the low capture numbers in 1997. No sheefish were netted in the subsistence fishery during event 1, because the subsistence fishery targets salmon and whitefish during this time. During the second event 34% of the sheefish examined were captured by subsistence gillnet, 5% by hook and line, and 61% by seine. The recapture rate for fish originally captured with seine was significantly greater than those originally captured with hook and line (χ^2 = 8.361, P = 0.004) (Table 2).

Table 2.-Recapture rate of sheefish during sampling in 1997.

	Recaptured			Recapture
Marking gear	No	Yes	Total	rate
Hook and Line	1,654	64	1,688	0.021
Seine	64	5	69	0.080
	1,718	39	1,757	

The probability of sheefish being recaptured by a different gear than by which the sheefish was originally captured was not significant (χ^2 = 0.030, P = 0.862) (Table 3). This indicates an overlap of gear types and that one gear was not more prone to capture previously tagged sheefish.

Table 3.-Gear by which sheefish were marked and recaptured.

	Gear of recapture		
Gear of capture	Gillnet	Seine	Total
Hook and line	15	19	34
Seine	2	3	5
Total	17	22	39

The condition that recruitment did not occur between sampling events was not violated. There was no significant difference in the marked to unmarked ratio by section during each week of event 2 (section 2: χ^2 = 3.150, P = 0.08; section 3: χ^2 = 2.323, P = 0.13), therefore recruitment to the population was unlikely. Since the subsistence gillnet fishery did not target sheefish during the first event, it was assumed that mortality during event 1 was negligible. Therefore, since both mortality and recruitment did not simultaneously occur during either event, the abundance estimate is germane to the time of the marking event (July 28 - September 17, 1997). Catches of sheefish in section 1 dropped significantly by the end of the marking event, consequently all spawning sheefish were considered to be on the spawning grounds prior to the start of the recapture event and immigration during that event was not a factor.

There was a significant difference in the marked-to-unmarked ratio in sections 2 and 3 (χ^2 = 5.293, P = 0.02), therefore the capture probability of marked fish was not similar among river sections (Table 1). This indicates that movement and/or complete mixing of marked and unmarked fish did not occur across river sections and catchability of marked and unmarked fish was unequal. Of the 39 sheefish marked during the first event and recaptured during the second, 66% moved upstream to another section, 31% stayed within the section in which it was marked, and 3% moved downstream (Table 4). This indicates an upstream movement between sections and this has occurred during each year of the study (Taube 1995, 1996). Fish originally marked in section 3 had a significantly greater recapture rate than those sheefish marked in the other sections (χ^2 = 9.583, P = 0.008).

Table 4.-Number of marked sheefish recaptured by river section in 1997.

River section marked	River section recaptured		
	2	3	Total
1	2	6	8
2	9	18	27
3	1	3	4
Total	12	27	39

Sheefish originally marked in section 1 had the lowest recapture rate (Table 5). Since movement upstream occurs as the spawning period approaches, those fish in the lower sections (1 and 2) would be less likely to be caught in the same section as they were marked, whereas those fish marked in section 3 where the majority of spawning occurs, would be more likely to be recaptured in the same section they were marked. It is thought that sheefish do not migrate above the upper boundary of the study area (sheefish have not been found above Reed River during any year of the study). Based on lack of sheefish captured in section 1 during the second event, it is assumed that sheefish remained within the study area during sampling. Since migration out of the study area did not occur, condition 4 was not violated and stratification by river section for the abundance estimate was not necessary. The greatest distance traveled by a marked sheefish until recapture was 86 km (54 mi); the least distance traveled by marked sheefish (five fish) was 0 km. Twelve sheefish traveled 5 km or less from the time of marking to the time of recapture. The average number of days between marking and recapture for these 12 sheefish was 20.5. On the average, marked sheefish traveled 30 km (19 mi) from the point of marking to point of recapture. The greatest number of days between marking and recapture

Table 5.-Recapture rate of sheefish by river section originally marked.

River section marked	Recaptured		Recapture rate
	No	Yes	
1	591	8	0.014
2	1,079	27	0.025
3	48	4	0.083
Total	1,718	39	

was 53; the least was 7. On the average, marked sheefish were recaptured 28 days after initial marking.

There was a significant size selectivity among gear types (χ^2 = 18.277, P = 0.019); this was most likely due to the large sample size (Table 6).

Table 6. Length composition of sheefish by gear types.

Length category (mm)	Gear			
	Gillnet	Hook & Line	Seine	Total
700 – 799	44	214	71	329
800 – 899	110	698	194	1,002
900 – 999	70	653	194	917
1,000 – 1,099	26	137	42	205
>1,100	4	23	14	41
Total	254	1,725	515	2,494

There was not a significant difference between the lengths of sheefish marked during the first event and marked sheefish recaptured during the second event (D = 0.13, P = 0.53). There was not a significant difference in lengths of fish marked during the first event and fish examined during the second event (D = 0.06, P = 0.06). According to the criteria followed to detect bias due to unequal catchability by length, stratification by length was not necessary for the abundance estimate (Appendix C2). The lengths and ages from both sampling events were pooled to improve precision of proportions in the estimates of length and age composition. The abundance of spawning sheefish in the Kobuk River between Kobuk Village and Reed River in 1997 was 32,511 (24,480 - 40,542 90%CI).

Age and Length Composition

Kobuk River

Length and age composition samples were taken from all unique sheefish examined during both sampling events. The largest proportion of sheefish in the population was in the 900 mm category (876 mm – 900 mm) ($\hat{p}$ = 0.11, SE = 0.006) (Figure 3). The largest proportion of female sheefish in the sample was in the 925 mm category ($\hat{p}$ = 0.22, SE = 0.014) and in the 775 mm category for the male sheefish ($\hat{p}$ = 0.16, SE = 0.009). Length distribution of female sheefish examined was significantly different than that of male sheefish (D = 0.729, P < 0.000) (Figure 3). The mean length of all sheefish examined was 844 mm (n = 2,500). Mean length of male sheefish was 797 mm (n = 1,492) and 921 mm (n = 886) for females. Sex was not determined for 122 sheefish examined during sampling.

The ages of all sheefish examined ranged from 8 to 21 years; male sheefish ranged in age from 8 to 20 years, while female sheefish ranged from 9 to 21 years. The largest proportion of male sheefish was age 11 ($\hat{p}$ = 0.28, SE = 0.018) and female sheefish was age 13 ($\hat{p}$ = 0.22, SE = 0.023). Age 11 ($\hat{p}$ = 0.22, SE = 0.013) fish were the largest proportion of all 987 sheefish scale samples examined (Figure 4).

Sex composition of sheefish examined during the second event in 1997 was 63% male and 37% female (SE = 0.01), compared to 53% female and 47% male in 1996 (SE = 0.02), and 54% male and 46% female in 1995 (SE = 0.02). Alt (1969) also reported a composition of 54% male and 46% female sheefish in the area of the Kobuk River spawning grounds.

Eight of 608 sheefish marked in 1994, 22 of 1,373 sheefish marked in 1995, and 13 of 2,212 sheefish marked in 1996 were captured during sampling in 1997 (Table 7). Of the eight sheefish marked in 1994 and recaptured in 1997 only one was female. Six of the 22 marked in 1995 and recaptured in 1997 were female. All 13 of the sheefish marked in 1996 and recaptured in 1997 were male. Contribution of the 1995 and 1996 spawning sheefish to the 1997 spawner abundance was 0.210 and 0.096, respectively. Examination of this data for frequency of spawning by sex was inconclusive. The data was confounded by the probability of tag loss increasing over several years and the possibility of spawning intervals greater than two years resulting in limited sample size.

During 1995 and 1996 fall and winter sampling, 64 paired samples of scales and otoliths were collected from sheefish mortalities. On the average, sheefish otoliths aged 2.6 years older than scales, the greatest discrepancy was 15 years difference between scale and otolith. Scale age for the sample ranged from age 5 to age 14, whereas otolith age ranged from age 7 to age 27. A plot comparing scale and otolith ages is found in Figure 5.

Sixty-three percent of all sheefish marked during the first event were captured around 62 - 64 km (river mile 39 and 40) above Kobuk Village; this area was the main holding area for sheefish during August and early September and the site of the project base camp. Forty-three percent of all sheefish examined during the second event were captured around 93 - 96 km (river mile 58 - 60) above Kobuk Village; this area was a primary spawning/holding area for sheefish in September. A total of 755 sheefish captured by subsistence gillnets was examined during the recapture event; lengths were obtained from only 253 of these and only these fish were used in the estimate of abundance. In 1995, 19% and 20% of the sheefish examined from the subsistence

Table 7.-Number of sheefish marked in previous years that were recaptured on the Kobuk River during sampling in 1997.

Recaptured in 1997	Year sheefish were marked		
	1994	1995	1996
yes	8	22	13
no	600	1,351	2,199
Number marked	608	1,373	2,212
1997 contribution	-[a]	0.210	0.096
Estimated abundance	-[a]	32,273	40,036

[a] No estimate of abundance was calculated for 1994, so contribution of 1994 spawners in 1997 could not be calculated.

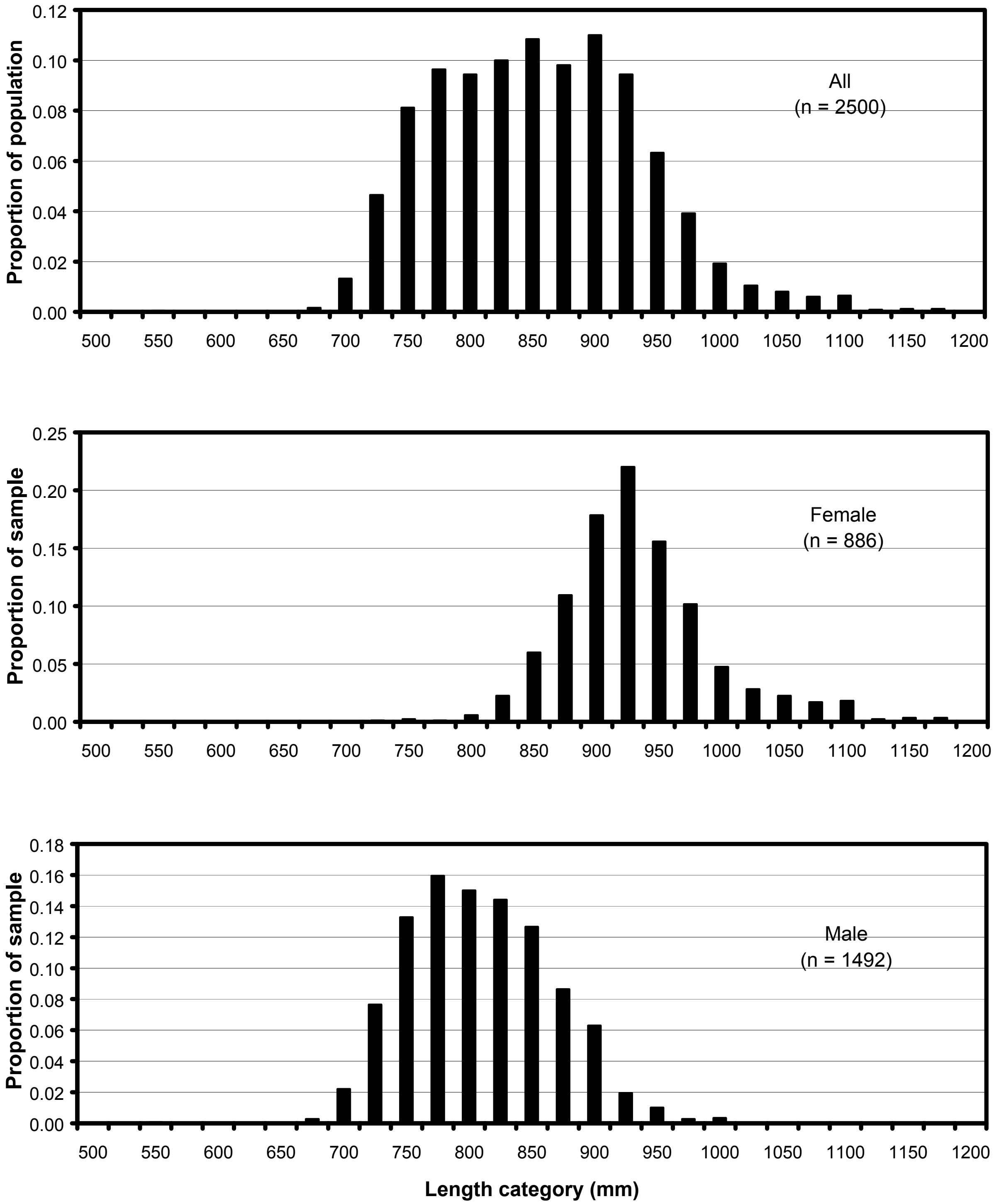

Figure 3.-Length composition of sheefish examined from the Kobuk River during sampling in 1997.

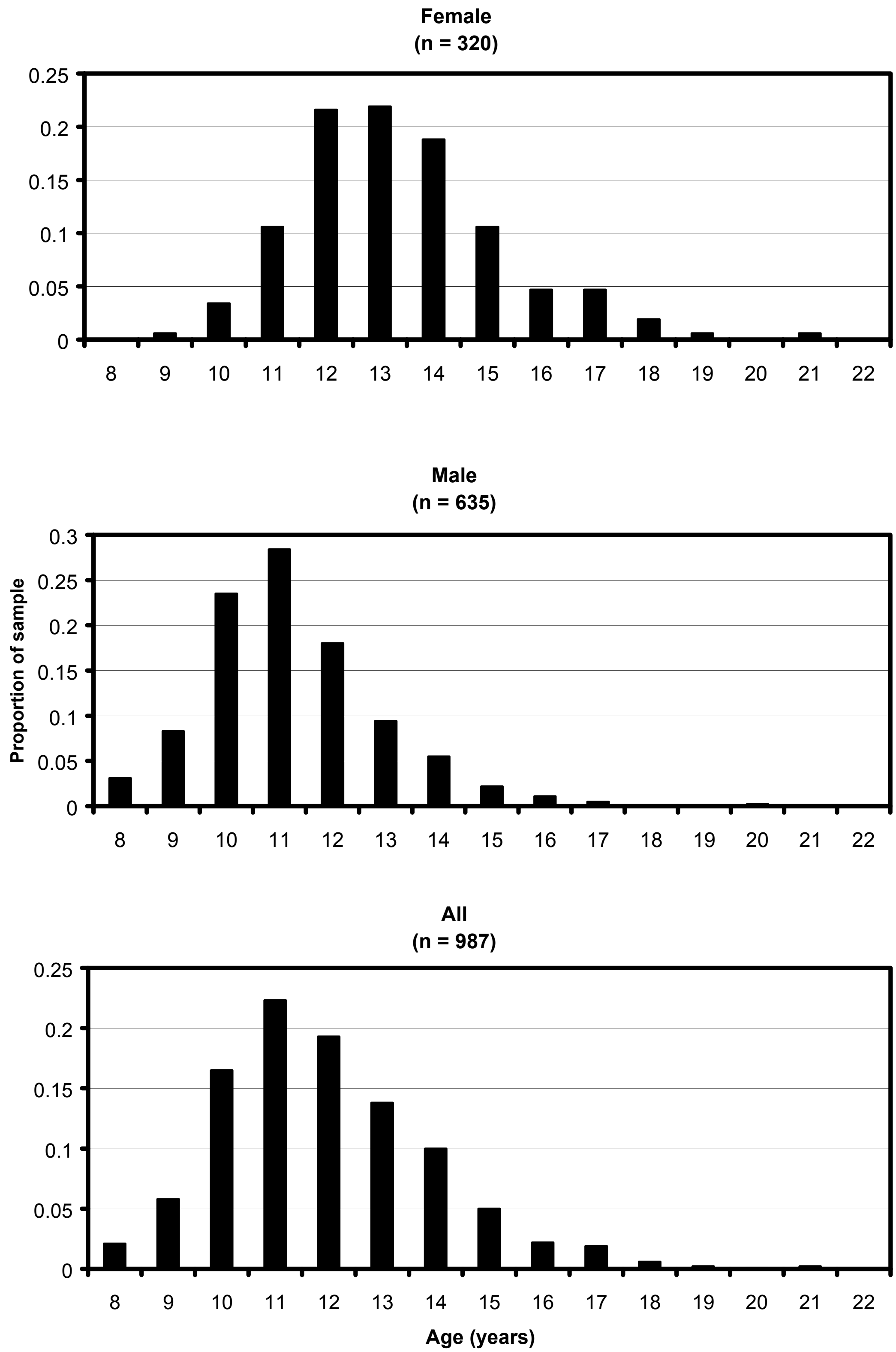

Figure 4.-Age composition of sheefish examined from the Kobuk River during sampling in 1997.

Figure 5.-Plot of otolith vs scale ages from paired samples collected from sheefish during 1995 – 1996 sampling.

fishery were captured at 64 km and 96 km above Kobuk Village, respectively. Unlike 1996, low water level on the Kobuk River in 1997 was not a problem for access to the upper river by subsistence users. Subsistence gillnets were much more distributed throughout the upper two study sections than any of the previous study years. Gillnet harvests were examined from 11 river mile sites in 1997. In previous study years, six (1995) was the greatest number of sites gillnets had been fished. Other sites at which sheefish were captured (during either event) in 1997 are found in Appendix D. Appendices E & F consist of age and length data, and tags deployed by year, respectively.

Hotham Inlet

Eighteen of 22 participants in the subsistence gillnet fishery on Kobuk Lake were interviewed during April 1997. The 18 survey participants fished 26 nets and the average number of days nets were fished was 75. The gillnet fishery usually occurs from early November through late April. An average of 623 sheefish were harvested by the survey participants. The estimated total harvest for the 1996 - 1997 subsistence gillnet fishery was 13,704 sheefish (95% CI 9,880 - 17,528). Data files used in the preparation of this report are found in Appendix G.

DISCUSSION

Tag loss within the sampling period did not appear to be a problem in 1997, or in any of the previous study years. No sheefish captured had secondary marks without having a Floy tag. Mortality due to sampling was low; no immediate mortalities occurred in sheefish captured by seine. Less than 0.5% of sheefish captured by hook and line died due to sampling method (16 of 1,768). Several fish were released that had been bleeding from the gills, but they were not tagged. These fish were held in the water alongside the boat until they swam away strongly. It was assumed that they survived, since the bleeding had stopped and the sheefish swam away. There were no reports from other users of the river that tagged sheefish were observed behaving erratically or found dead. It is therefore believed that short-term mortality due to handling and sampling methods was negligible. A hooking mortality study conducted concurrently found less than 5% mortality in sheefish capture by single and treble hook lures after a 48 h period (Stuby and Taube 1998).

Age determination by otolith resulted in greater age for sheefish than age from scales. Ten otolith (five male, five female) samples were sent to a USFWS researcher for microprobe analysis and thin section aging (Randy Brown, USFWS memorandum). Ages of sheefish from the thin section technique compared to the break and burn technique resulted in greater age estimates in seven of the 10 samples (2.1 years older on average). The oldest sheefish aged by otolith (64 samples - break and burn technique) was 27, the oldest by scale aging technique from all samples collected during the study was 23. If otoliths are representative of true age, then Kobuk River sheefish live several years longer than previously thought. There was difficulty in collecting paired samples of scales and otoliths, since the subsistence users preferred samplers to handle fish as little as possible. Two otolith samples (one male, one female) were examined for strontium levels to determine if time was spent in high salinity waters (Kotzebue Sound). The results indicate that some time is spent in saline water within most years, but further sampling would be required to determine whether the time was in brackish water (Hotham Inlet) or seawater (Kotzebue Sound).

During sampling in 1996, tag returns from sheefish marked in previous years (1994 and 1995) suggested that non-consecutive spawning occurs in Kobuk sheefish (Taube 1997). It was hoped that tag returns in 1997 from sheefish marked in previous years might give some insight to length of spawning intervals of Kobuk River sheefish. Based on the examination of tag returns from previous years in 1997 for determination of frequency of spawning by sex, the probability of recapturing a sheefish marked in a previous year was very small (Pat Hansen, ADF&G memorandum). This could be due to 1) high mortality rate, 2) tag loss between years, 3) fish not available for capture every year (timing of sampling, gear selectivity or shyness, lack of loyalty to the spawning grounds), or 4) the fish are gone more than 2 years before returning.

In reference to high mortality rates, subsistence harvests during 1994-1996 have averaged 6,533 sheefish. These are the years the sheefish tagged during the study would have been harvested before returning to spawn in 1997. For 1995 and 1996 (no abundance estimate in 1994), percentage of the estimated abundance of spawners that may have been harvested was 29% (9,465 of 32,273) and 16% (6,953 of 43,036), respectively. The percentage of tags deployed during sampling and harvested in the fall subsistence fishery during 1995 and 1996 was 3% and 2%, respectively. Non-reporting of harvested tags and tag loss in subsistence gillnets could account for the difference between percentages. During the study, subsistence users often told the sampling crew of difficulty in spotting the gray Floy tags on sheefish. This could result in many tagged fish not being spotted by the subsistence users. For this reason, only subsistence fish examined by the sampling crew were included for the abundance estimate.

Secondary marks (fin clips and punches) were not observed on fish recaptured from previous years. Sheefish that had been tagged in previous years could only be identified if the Floy tags were in place. It is likely that tag loss over several years may be relatively high; sheefish migrate 600 km to the spawning grounds and the rigors of the spawning migration could result in tag loss. As stated previously, Floy tags, gray in color, were used during the study as well as less noticeable secondary marks (unlike adipose fin clips) at the request of the subsistence users of the Kobuk River; so the study would be less intrusive to their subsistence resource. Future studies relying on tag retention and visibility will need to address this potential research conflict.

If fish were not available for capture every year, it was likely a result of mortality, tag loss, or non-consecutive spawning. Sampling was conducted at the same period every year, as fish were entering the spawning grounds and until spawning occurred. The sampling gear was the same in every year and multiple gear types were used to prevent gear avoidance. From tag recoveries in previous years, no Selawik River spawners were captured on the Kobuk River spawning grounds and no Kobuk River spawners were captured on the Selawik River spawning grounds. In addition, genetic samples collected in 1993 and 1994 indicate that sheefish from these systems are separate spawning stocks (Miller et al. 1998). Discussions with Kobuk River residents and previous sheefish research (Alt 1987) indicate that spawning occurs only within the study area. This information indicates that sheefish are loyal to the spawning grounds.

During 1995-97, sheefish of both sexes, marked in the previous year were captured the following year. Taube (1997) reported that based on the proportion of sheefish marked in 1994 and 1995 returning in 1996 suggested non-consecutive spawning, although males were more likely to return the following year than females. Based on the 1997 tag return data, the spawning interval of Kobuk River sheefish could be greater than 2 years. This corroborates the research conducted by Alt (1987) on the Kobuk-Selawik population. In some Russian populations, sheefish are believed to spawn every 3 to 4 years (Nikol'skii 1954). Scott and Crossman (1973) reported that sheefish were believed to spawn every 2-4 years in Canadian populations. Based on the fact that some sheefish were recaptured the next year on the spawning grounds, the spawning interval for sheefish may be variable, dependent on condition of the fish prior to the spawning migration. Alt (1987) reported immature and non-consecutive spawning sheefish migrating into the lower reaches (80-km) of the Kobuk River. Winter subsistence fishers on Hotham Inlet interviewed during the harvest surveys reported skinny sheefish being caught in the gillnets early in the season (November and December). It is likely that these fish are the prior fall spawners, and some of the fish may require more than one winter of feeding to rebuild energy reserves necessary to make the full spawning migration and in the following spring, remain in the lower river to continue feeding. To determine actual spawning intervals, long term tagging (using a more permanent tag than Floy tags) or radio-telemetry studies should be considered.

The ratio of male to female sheefish on the spawning grounds in 1997 was different from previous study years and between 1995 – 1997 no two years had a similar ratio. Kirilov (1962) reported 65% males and 35% females in the Vilyui River, but mentioned that the sex ratio changed from year to year. Following sampling in 1996 it was suggested that non-consecutive spawning may be responsible for the variation between years and the ratio of males to females on the spawning grounds may not be indicative of the male:female ratio for all spawners in the population (Taube 1997).

Abundance of spawning sheefish in 1995 – 1997 was not significantly different between years, although the point estimate in 1996 (43,036) was substantially higher than 1995 and 1997 (32,327 and 32,680, respectively). It appears that spawning interval of individual spawners does not directly affect the numbers of sheefish returning to the spawning grounds in a given year. The number of spawners in the Kobuk River may be a factor of the availability of suitable spawning habitat, rather than influenced by spawning interval. This would be supported by the estimated abundance of spawners in the Selawik and Kobuk rivers (Underwood et al. 1998, Taube 1995, 1996) and the amount of spawning habitat reported by Alt (1987) in those systems.

The winter subsistence gillnet harvest on Hotham Inlet in 1996-97 was not significantly different from the harvest in 1995-96. The number of participants in the fishery declined by three in 1996-97. Based on tag returns from Hotham Inlet fisheries (winter gillnet and hooking), both Kobuk and Selawik river spawners use Hotham Inlet and Selawik Lake as a overwintering area. Thirty-one percent of tags returned in 1995-96 and 20% returned in 1996-97 were from sheefish tagged on the Selawik River spawning grounds. Eight tags were recovered from the Selawik Lake hooking fishery in 1995 – 96 and three of these were tagged on the Kobuk River spawning grounds in 1995. Concern of overharvest of the Selawik spawning stock in the winter fishery has arisen with information collected from the ADF&G and USFWS projects (Miller et al. 1998). If the tag returned data from the winter fisheries is directly applicable, there does appear to be a higher proportion of Selawik spawners harvested in the winter fishery than is represented in the spawning populations. Data collected from the Selawik hooking fishery is limited, since effort in both years of the survey was directed solely to Hotham Inlet and tag recovery from the Selawik was passive, therefore any management decisions based on this data should be limited, until this data can be verified. The proportion of immature fish harvested from the spawning sites are unknown, and dependent on what habitat is important to immature sheefish, the immature Selawik stock may not have the same harvest proportion. Alt (1987) reported that a small amount of under the ice gillnetting occurred in the lower Selawik River in October and November. A discussion with a Selawik resident revealed that the under the ice gillnet fishery does not occur in the lower Selawik River anymore, all winter/early spring harvests are by hooking (Ralph Ramoth, personal communication). The hooking fishery harvest was not estimated during any year of this study, the catch was sampled during 1995-96 and determined that both immature and mature sheefish are harvested (Taube 1997). Since the hooking fishery occurs over a long period (late March – early May) and a large area (Selawik Lake and Hotham Inlet) a end of season survey in the Kotzebue district villages may be the most feasible way to estimate harvest. The majority of the winter sheefish harvest is believed to be taken by this fishery (Alt 1987).

Sheefish have been reported caught in nets in the Buckland River in the fall of 1997 and near Deering (Ralph Ramoth, personal communication). A fresh water lens flows from Hotham Inlet into Kotzebue Sound and may provide a corridor for sheefish to migrate to new river systems. This may indicate expansion of the sheefish range in the Kotzebue Sound area. Further research using strontium testing and microprobe analysis may provide information on whether sheefish utilize the waters of Kotzebue Sound for any part of their life history. Minimal data has been collected on the location and habitat of juvenile and immature sheefish; future studies should be directed in this area to prevent damage to unknown rearing habitats. Current sport, commercial, and subsistence harvest data exhibit a decline in overall sheefish harvest since the 1970's. Subsistence harvests have increased during the past three years and whether this is indicative of a upward harvest trend is unclear. Since total subsistence harvest has not been estimated since 1967 (Alt 1987), a current total harvest estimate would better indicate changes in harvest over time.

ACKNOWLEDGMENTS

A note of appreciation to the field crew who conducted the sampling: Richard Barnes, Mike Doxey, Jim Fish, Amber Kocsis, Tracy Lingnau, Don Roach, Corey Schwanke, Dave Stoller, Lisa Stuby, Klaus Wuttig, and Randy Zarnke (ADF&G), Kenny Barr, Samantha Smith, Alex Carter, Lance Astles, Leslie Ruiz, Peter Christiansen, Dave DeVoe, Liz Evenson, Matt Irinaga, Chris McKee, Jeff and Amy Mow (Gates of the Arctic, National Park Service), and Ken Alt (ADFG-retired) who tagged sheefish in August/September, 1997. Thanks to Lisa Stuby (ADF&G) for aging sheefish scales and Patty Rost (NPS) for her coordination of the Gates of the Arctic-NPS personnel and funding which without this project would not have been successful. Thanks also to Fred DeCicco for his assistance in logistics and planning, and Dave Bernard, Pat Hansen, and Mike Wallendorf for his biometrical assistance, Susan Bucknell, Kathy Sherman, and Tracy Lingnau, for their assistance during the spring survey and tag recovery, and Dr. Margaret Merritt for editorial expertise on this manuscript and assistance in the coordination of the project. Thanks to Tracy Lingnau (ADF&G-CFMD) for his assistance in logistics in Kotzebue during fall and spring sampling. A special thanks to the residents of the communities along the Kobuk River who allowed the field crew to sample their subsistence catch and provided additional information on Kobuk River sheefish.

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APPENDIX A

Appendix A 1.-Sheefish sport fish harvests and catch, 1977-96 (Mills 1977-94, Howe et al. 1995-97).

Year	Kobuk River Harvest	Kobuk River Catch[a]	NW Alaska Harvest	NW Alaska Catch[a]	Alaska Harvest	Alaska Catch[a]
1977	625	-	656	-	1,247	-
1978	307	-	506	-	1,291	-
1979	682	-	709	-	1,542	-
1980	1,248	-	1,713	-	2,411	-
1981	1,015	-	1,263	-	2,239	-
1982	1,886	-	2,222	-	3,281	-
1983	1,448	-	2,079	-	3,323	-
1984	740[b]	-	3,050	-	3,947	-
1985	1,330[b]	-	1,645	-	2,520	-
1986	1,590	-	3,363	-	3,721	-
1987	865	-	1,836	-	2,597	-
1988	964[b]	-	964	-	3,221	-
1989	131	-	629	-	2,306	-
1990	151	336	151	403	750	3,360
1991	579	1,568	603	1,616	2,256	3,989
1992	627	2,034	1,904	3,678	2,933	6,587
1993	395	1,074	1,029	2,273	1,619	6,666
1994	135	386	564	958	1,511	2,981
1995	748	2,669	1,142	3,270	2,200	6,623
1996	245	1,146	362	1,458	748	3,442

a Sport fish catch was not reported until 1990.

b Sheefish harvest is for streams of NW Alaska.

Appendix A 2.-Reported subsistence sheefish harvests, Kotzebue District, 1966-1997 (taken from Lean et al. 1996)[a].

Year	Number of Fishermen Interviewed	Reported Harvest	Average Catch Per Fishermen
1966-67	135	22,400	166
1967-68	146	31,293	214
1968-69	144	11,872	82
1970	168	13,928	83
1971	155	13,583	88
1972	79	3,832	49
1973	65	4,883	75
1974	58	1,062	18
1975	69	1,637	24
1976	57	966	17
1977	95	1,810	19
1978	95	1,810	19
1979	75	3,985	53
1980	74	3,117	42
1981	62	6,651	107
5/82-4/83[b]	130	4,704	36
5/83-4/84[b]	27	764	28
5/84-9/84	30	2,803	93
1985[c]	2	60	30
1986[b,c]	72	721	10
1987[c]	46	276	6
1988[c,d]	-	-	-
1989[c]	-	-	-
1990[c]	-	-	-
1991	40	2,180	55
1992	43	2,821	66
1993[d]	-	-	-
1994[e]	226 (379)	3,181	8.4
1995[e]	314 (385)	9,465	24.6
1996	389	6,953	18
1997	338	9,805	24.6

[a] Due to limited survey effort during many years total catch and effort should be regarded as minimum figures only and are not comparable from year to year.

[b] Summer catches only; winter catches were not documented.

[c] Villages were not surveyed for subsistence sheefish harvests from 1985 to present; figures shown are catches reported during the fall chum salmon subsistence surveys, and may include summer as well as winter catches.

[d] Subsistence sheefish catches not documented.

e Reported harvest is estimated and based on the total number of households in all communities (in parentheses).

Appendix A 3.-Kotzebue District winter commercial sheefish harvest statistics, 1967-96 (taken from Lean et al. 1996)[a].

Year[b]	No. of Fishermen	No. of Fish	Total Pounds	Average Pounds	Price/Pound	Estimated Value
1967[c]		4,000	26,000	6.5	$0.20	$5,200
1968	10	792	4,752	6.0	$0.22	$1,045
1969	17	2,340	15,209	6.5	$0.25	$3,802
1970[c]		2,206			$0.14	
1971	4	73	720	9.9	$0.13	$95
1972	5	456	4,071	8.9	$0.16	$651
1973	11	2,322	15,604	6.7	$0.20	$3,121
1974	6	1,080[d]	6,265	5.8	$0.30	$1,880
1975	[c]	2,543[d]	24,161	9.5	$0.30	$7,248
1976	14	2,633	19,484	7.4	$0.30	$5,845
1977	2	566	5,004	8.8	$0.30	$1,501
1978	11	2,870	26,200	9.1	$0.40	$10,480
1979[e]						
1980	4	1,175	8,225	7.0	$0.50	$4,113
1981	1	278	1,836	6.6	$0.75	$1,377
1982	11	2,629[f]	17,376	6.6	$0.75	$13,032
1983	8	1,424	13,395	9.4	$0.50	$6,698
1984	5	927[d]	10,403	11.2	$0.55	$5,722
1985	4	342[d]	3,902	11.4	$0.51	$1,990
1986	2	26	312	12.0	$0.75	$234
1987	3	670	5,414	8.1	$0.49	$2,653
1988	3	943	7,373	7.8	$0.45	$3,318
1989	8	2,335	16,749	7.2	$0.51	$8,542
1990[c]	6	687	5,617	8.2		

-continued-

Appendix A 3.-Page 2 of 2.

Year[b]	No. of Fishermen	No. of Fish	Total Pounds	Average Pounds	Price/Pound	Estimated Value
1991	5	852	8,224	9.7	$0.50	$4,112
1992	3	289	2,850	9.9	$0.65	$1,853
1993	1	210[d]	1,700	8.1	$0.50	$850
1994[e]						
1995	1	226	2,240	9.9	$0.50	$1,120
1996	2	308	3,002	9.7	$0.44	$1,321

[a] Data is not exact, in some instances total catch poundage was determined from average weight and catch data. Similarly, various price/pound figures were determined from price/fish and average weight data.

[b] Season was from October 1 to September 30. Year indicated would be the year the commercial season ended. For example, the year 1980 would represent October 1, 1979 to September 30, 1980.

[c] Data unavailable or incomplete.

[d] Numbers of fish not always reported. Estimates were based on average weights from reported sales which documented the number of fish.

[e] No reported commercial catches.

[f] Estimate based on historical average weight.

APPENDIX B

Appendix B 1.-Interview form used for Kobuk Lake gillnet fishery harvest survey.

Hotham Inlet Sheefish Harvest Assessment

1996 - 1997 Kobuk Lake Gillnet Fishery interview form

Community __Kotzebue__ Interviewer________________ Date ________

I would like to ask you a few questions about the sheefish you caught by gillnet this winter in Kobuk Lake.

How many gillnets did you fish?__________

What day did you set your nets?________________________________

What day did you pull your nets?________________________________

How many sheefish did you harvest through the ice by gillnet during the winter of 1996-97? __________

Did anyone else fish your net? __________

Does your total harvest include their harvest? __________ If no, who else fished your net?__________

____

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____

Did you catch any sheefish with tags? __________ If so, did you report the tag to the Kotzebue -ADFG office? __________ If not, do you still have the tag and what is the number?________________

____

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Do you have any comments or concerns about sheefish fishing in Kobuk Lake (Hotham Inlet)?

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APPENDIX C

Appendix C 1.-Methodology to alleviate bias due to unequal catchability by river section.

Result of χ^2 Test[a]	Inspection of Fish Movement[b]
Case I:	
"Accept H_o"	No movement between sections

There is no differential capture probability by river section or marked fish completely mixed with unmarked fish within each river section.

Case II:	
"Accept H_o"	Movement between sections

There is no differential capture probability by river section or marked fish completely mixed with unmarked fish across river sections.

Case III:	
"Reject H_o"	No movement between sections

There is differential capture probability by river section or marked fish did not mix completely with unmarked fish within at least one river section.

Case IV:	
"Reject H_o"	Movement between sections

There is differential capture probability by river section or marked fish did not mix completely with unmarked fish across river sections.

[a] The χ^2 test compares the frequency of marked fish recaptured during the second event in each river section with the frequency of unmarked fish examined in the second event in each river section. H_o: the capture probability of marked fish in the second event is the same in all river sections.

[b] Inspection of fish movement is a visual comparison of the frequency of marked fish recaptured in the second event that moved from one river section to another with the frequency of unmarked fish examined in the second event in each river sections.

Case I: Calculate one unstratified abundance estimate using the Petersen estimator (Seber 1982).

Case II: Calculate one unstratified abundance estimate using the Petersen estimator (Seber 1982).

Case III: Completely stratify the experiment by river section , calculate abundance estimate for each using the Petersen estimator (Seber 1982), and sum abundance estimates.

Case IV: Completely stratify the experiment by river section . Calculate abundance estimates for each using the Petersen estimator (Seber 1982) and sum estimates. Calculate abundance with the partially stratified model of Darroch (1961) and compare with the sum of Petersen estimates. If estimates are dissimilar, discard the sum of Petersen estimates and use the Darroch estimate as the estimate of abundance. If estimates are similar, discard the estimate with the largest variance.

Appendix C 2.-Methodologies for alleviating bias due to gear selectivity by means of statistical inference (Bernard and Hansen 1992).

Results of Hypothesis Tests (K-S and χ^2) on Lengths of Fish Marked during First Event and Recaptured during Second Event	Results of Hypothesis Tests (K-S) on Lengths of fish Captured during First Event and during Second Event
Case I:	
"Accept" H_o	"Accept" H_o
There is no size-selectivity during either sampling event.	
Case II:	
"Accept" H_o	Reject H_o
There is no size-selectivity during the second sampling event but there is during the first.	
Case III:	
Reject H_o	"Accept" H_o
There is size-selectivity during both sampling events.	
Case IV:	
Reject H_o	Reject H_o
There is size-selectivity during the second sampling event; the status of size-selectivity during the first event is unknown.	

Case I: Calculate one unstratified abundance estimate, and pool lengths, sexes, and ages from both sampling events to improve precision of proportions in estimates of composition.

Case II: Calculate one unstratified abundance estimate, and only use lengths, sexes, and ages from the second sampling event to estimate proportions in compositions.

Case III: Completely stratify both sampling events, and estimate abundance for each stratum. Add abundance estimates across strata to get a single estimate for the population. Pool lengths, ages, and sexes from both sampling events to improve precision of proportions in estimates of composition, and apply formulae to correct for size bias to the pooled data.

Case IV: Completely stratify both sampling events and estimate abundance for each stratum. Add abundance estimates across strata to get a single estimate for the population. Also, calculate a single estimate of abundance without stratification.

Case IVa: If the stratified and unstratified abundance estimates for the entire population are dissimilar, discard the unstratified estimate. Only use the lengths, ages, and sexes from the second sampling event to estimate proportions in composition, and apply formulae to correct for size bias to data from the second event.

Case IVb: If the stratified and unstratified abundance estimates for the entire population are similar, discard the estimate with the larger variance. Only use the lengths, ages, and sexes from the first sampling event to estimate proportions in compositions, and do not apply formulae to correct for size bias.

APPENDIX D

Appendix D 1.-Sampling and subsistence sheefish catch by event, gear type, and river mile[a] during 1997.

River	Event 1 July 28 - August 6, August 15 - September 17		Event 2 September 18-29			Total
Mile	H & L	Seine	H & L	Seine	Gillnet	Catch
4	351	0	0	0	0	351
13	1	0	0	0	0	1
14	8	0	0	0	0	8
24	1	0	0	0	0	1
25	1	0	0	0	0	1
29	192	0	0	0	0	192
30	46	0	0	0	0	46
31	1	0	0	0	0	1
33	1	0	0	0	0	1
35	5	0	0	0	0	5
39	642	0	0	3	0	645
40	429	27	8	68	49	581
41	2	0	0	0	0	2
52	3	0	0	15	7	25
55	0	0	0	0	0	0
56	0	1	0	4	1	6
57	0	0	2	14	18	34
58	0	39	8	54	29	130
59	4	2	4	41	14	65
60	0	0	6	111	50	167
63	1	0	5	49	29	84
70	0	0	4	52	27	83
73	0	0	2	20	20	42
75	0	0	1	19	9	29
Total	1688	69	40	450	253	2500

[a] River mile is the distance upstream of Kobuk Village.

APPENDIX E

Appendix E 1.-Length composition of sheefish examined during the sampling from the Kobuk River, July 28 - September 29, 1997.

	Female				Male				All Fish				
Length	Frequency	pij	V(pij)	SE	Frequency	pij	V(pij)	SE	Nj	V(Nj)	pj	V(pj)	SE
550	0	0	0	0	1	0.001	4.49E-07	0.0007	13	175	0.000	1.60E-07	0.0004
575	0	0	0	0	0	0	0	0	0	0	0.000	0	0.0000
600	0	0	0	0	0	0	0	0	0	0	0.000	0	0.0000
625	0	0	0	0	0	0	0	0	0	0	0.000	0	0.0000
650	0	0	0	0	0	0	0	0	0	0	0.000	0	0.0000
675	0	0	0	0	4	0.003	1.79E-06	0.0013	52	746	0.002	6.39E-07	0.0008
700	0	0	0	0	33	0.022	1.45E-05	0.0038	431	9861	0.013	5.21E-06	0.0023
725	1	0.001	1.27E-06	0.0011	114	0.076	4.73E-05	0.0069	1516	71976	0.046	1.77E-05	0.0042
750	2	0.002	2.54E-06	0.0016	198	0.133	7.72E-05	0.0088	2654	194401	0.081	2.99E-05	0.0055
775	1	0.001	1.27E-06	0.0011	238	0.160	8.99E-05	0.0095	3150	266281	0.096	3.49E-05	0.0059
800	5	0.006	6.34E-06	0.0025	224	0.150	8.56E-05	0.0093	3085	256184	0.094	3.42E-05	0.0058
825	20	0.023	2.49E-05	0.0050	215	0.144	8.27E-05	0.0091	3268	284945	0.100	3.60E-05	0.0060
850	53	0.060	6.35E-05	0.0080	189	0.127	7.42E-05	0.0086	3543	330935	0.108	3.87E-05	0.0062
875	97	0.110	1.10E-04	0.0105	129	0.086	5.30E-05	0.0073	3203	274499	0.098	3.54E-05	0.0059
900	158	0.178	1.66E-04	0.0129	94	0.063	3.96E-05	0.0063	3595	340082	0.110	3.92E-05	0.0063
925	195	0.220	1.94E-04	0.0139	29	0.019	1.28E-05	0.0036	3085	256184	0.094	3.42E-05	0.0058
950	138	0.156	1.49E-04	0.0122	15	0.010	6.68E-06	0.0026	2065	123753	0.063	2.37E-05	0.0049
975	90	0.102	1.03E-04	0.0102	4	0.003	1.79E-06	0.0013	1281	53971	0.039	1.51E-05	0.0039
1000	42	0.047	5.10E-05	0.0071	5	0.003	2.24E-06	0.0015	627	17134	0.019	7.54E-06	0.0027
1025	25	0.028	3.10E-05	0.0056	0	0	0	0	340	7064	0.010	4.12E-06	0.0020
1050	20	0.023	2.49E-05	0.0050	0	0	0	0	261	4969	0.008	3.18E-06	0.0018
1075	15	0.017	1.88E-05	0.0043	0	0	0	0	196	3436	0.006	2.39E-06	0.0015
1100	16	0.018	2.00E-05	0.0045	0	0	0	0	209	3727	0.006	2.54E-06	0.0016
1125	2	0.002	2.54E-06	0.0016	0	0	0	0	26	357	0.001	3.20E-07	0.0006
1150	3	0.003	3.81E-06	0.0020	0	0	0	0	39	548	0.001	4.80E-07	0.0007
1175	3	0.003	3.81E-06	0.0020	0	0	0	0	39	548	0.001	4.80E-07	0.0007
1200	0	0	0	0	0	0	0	0	0	0	0.000	0	0.0000
	886				1492				32680				

Appendix E 2.-Age composition of sheefish examined during sampling from the Kobuk River, July 28 - September 29, 1997.

	FEMALE				MALE				ALL				
Age	Frequency	pij	V(pij)	se	Frequency	pij	V(pij)	se	Nj	V(Nj)	pj	V(pj)	SE
8	0	0	0	0	20	0.031	4.7E-05	0.007	692	32609	0.021	2.09E-05	0.005
9	2	0.006	1.9E-05	0.004	53	0.083	1.2E-04	0.011	1878	136504	0.058	5.46E-05	0.007
10	11	0.034	1.0E-05	0.010	149	0.235	2.8E-04	0.017	5369	794469	0.165	1.38E-04	0.012
11	34	0.106	3.0E-04	0.017	179	0.284	3.2E-04	0.018	7247	1365588	0.223	1.76E-04	0.013
12	69	0.216	5.3E-04	0.023	114	0.180	2.3E-04	0.015	6259	1046054	0.193	1.57E-04	0.013
13	70	0.219	5.4E-04	0.023	60	0.094	1.3E-04	0.012	4480	576985	0.138	1.19E-04	0.011
14	60	0.188	4.8E-04	0.022	35	0.055	8.1E-05	0.009	3261	334337	0.100	9.23E-05	0.010
15	34	0.106	3.0E-04	0.017	14	0.022	3.3E-05	0.006	1614	108177	0.050	4.74E-05	0.007
16	15	0.047	1.4E-04	0.012	7	0.011	1.7E-05	0.004	725	34676	0.022	2.19E-05	0.005
17	15	0.047	1.4E-04	0.012	3	0.005	7.3E-06	0.003	626	28614	0.019	1.90E-05	0.004
18	6	0.019	5.7E-05	0.008	0	0	0	0.000	198	7212	0.006	6.07E-06	0.002
19	2	0.006	1.9E-05	0.004	0	0	0	0.000	66	2217	0.002	2.03E-06	0.001
20	0	0	0	0	1	0.002	2.4E-06	0.002	33	1085	0.001	1.02E-06	0.001
21	2	0.006	1.9E-05	0.004	0	0	0	0.000	66	2217	0.002	2.03E-06	0.001
22	0	0	0	0	0	0	0	0.000	0	0	0	0	0
Total	320				635				32514				

APPENDIX F

Appendix F.-Tags deployed by year on the Kobuk River during sampling, 1994-1997.

Year	Tag numbers	Color
1994	13000 – 13528	Gray
	13550 – 13607	Gray
	18002 – 18049	Gray
	18800 - 18822	Gray
1995	2101 – 2199	Gray
	2300 – 2370	Gray
	17075 – 17449	Gray
	17800 – 17999	Gray
	18100 – 18859	Gray
1996	31024 – 31050	Gray
	32000 – 34292	Gray
1997	40001 – 41433	Gray
	41501 – 42100	Gray
	49100 – 49199	Gray
	5910 – 5947	Green
	31881 – 31899	Green
	31911 – 31920	Green
	9750 – 9767	Blue
	9800 – 9814	Blue
	94932 – 94961	Blue

Appendix G

Appendix G.-Data files used in the preparation of this report.

Data File	Description	Status
X0040L-7.XLS	Sheefish biological data, Kobuk River 1997	Included